Smart Flexible Energy Solutions for the Future Energy System

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Smart Flexible Energy Solutions for the Future Energy System

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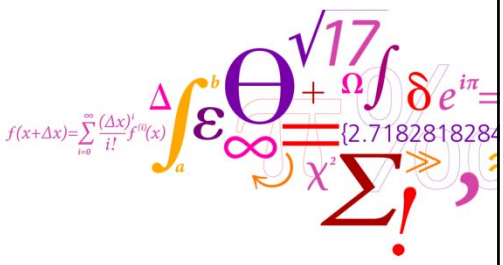
GENERAL CONVENTION
COPENHAGEN JUNE 12th TO 14th 2014



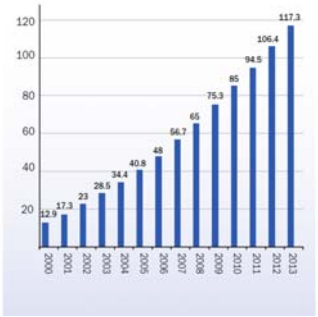
DTU Electrical Engineering
Department of Electrical Engineering

Wind Power in Denmark – it is here…

- Year 2013:
  - Danish wind power covered **33.2 %** of the electricity consumption
- January 2014:
  - Danish wind power covered **63.3 %** of the electricity consumption
- March 11th 2014:
  - Only **9 MW** out of 4,900 MW wind turbines generated power
  - But **480 MW** out of 580 MW solar PV supplied the grid

Renewable Energy Development in Europe

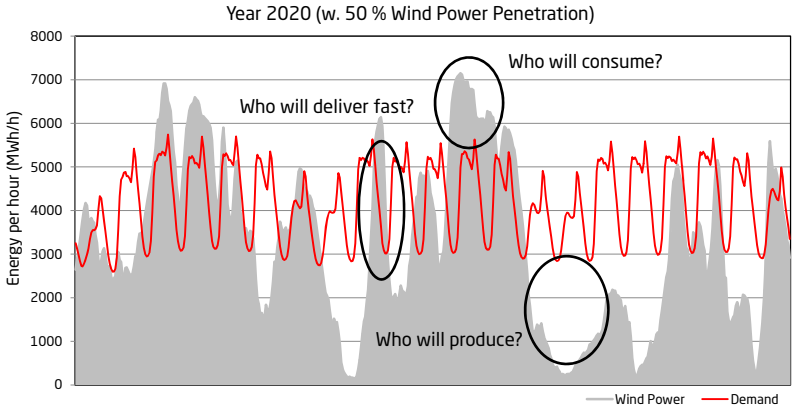
Cummulative wind power installations in the EU (GW)



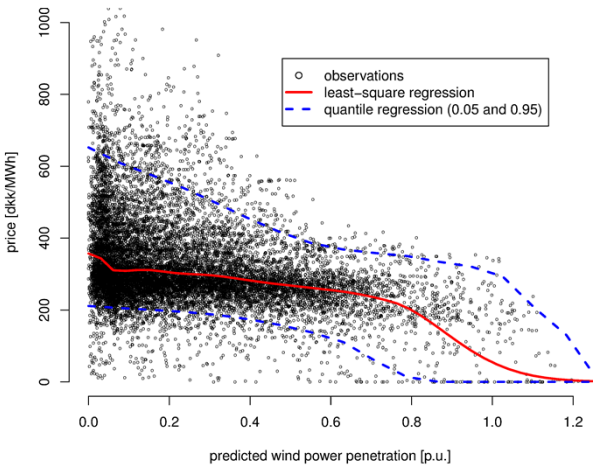
Ref.: EWEA

Ref.: The EU commission

The Challenges
Energy and Power Balancing



Impact of Wind Power on the Nordic Electricity Market Prices

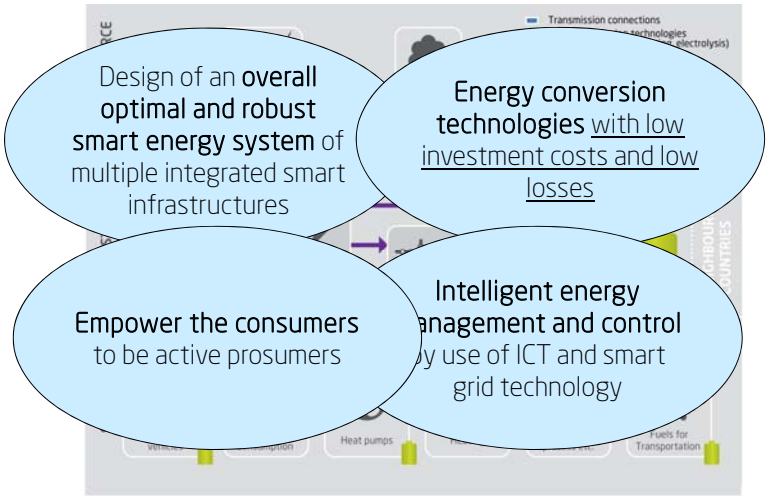


Source: Pinson et. al (2012). IEEE Power & Energy Society General Meeting 2012, San Diego, California, US.

Main Sources of Flexibility in the Future Energy System

- **Long distance power transmission cables** for balancing across regions (>500-1000 km)
- **Biomass** in the electricity generation
- **Flexible electricity demand** enabled through smart grid technology ('virtual storage' solutions, e.g. heating, cooling and Evs)
- **Energy storage technologies**; pumped hydro, compressed air, batteries etc.
- **Integration of multiple energy infrastructures** operating together in an optimal system (fuel-shift solutions)

Integration of the Energy Systems can provide Flexibility



Ref.: Østergaard et.al, 2013.

PowerLabDK

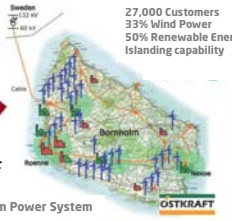
PowerLabDK combines experimental facilities

Flexible multi-purpose laboratories

Lyngby & Ballerup Campus

Large-scale test system

Risø Campus



27,000 Customers
33% Wind Power
50% Renewable Energy
Islanding capability

Full-scale Realistic Power System

Bornholm Power System

Stakeholders:

ABB, nkt cables, danskenergi, SIEMENS, DONG energy, VATTENFALL, ENERGINET.DK, Vestas, IBM

Supported by:

GREEN LABS DK, eUDP

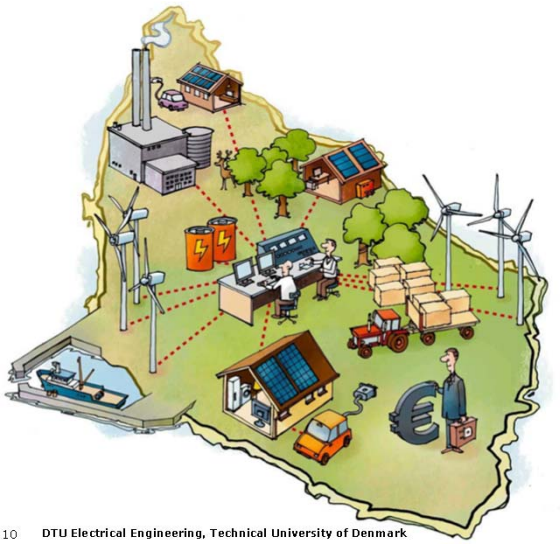
Investment:
18 million Euro

www.powerlab.dk

DTU Technical University of Denmark · INGENIØRHØJSKOLEN KØBENHAVN · ØSTKRAFT energi til gode oplevelser

Bornholm

Test-site for Distributed Energy with 25,000 customers and 50% Renewables

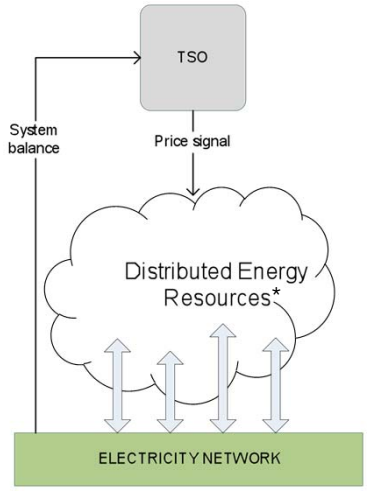


Resources:
- *Wind power*
- *Biomass*
- *Biogas*
- *District heating*
- *Combined heat and power*
- *Solar power*
- *eMobility*
- *Active demand*

Features:
- *Nord Pool market*
- *Islanding capability*

The EcoGrid EU Project - Large-scale Demonstration of the Future Intelligent Energy System

Demonstation with 2,000 customers at Bornholm



* Includes flexible demand

The new market enables DER to respond flexible on real-time price signals without direct control or on-line measurements

EcoGrid eu
www.eu-ecogrid.net

2,000 Participating Customers in the Demonstration

Statistic Control

200 households with smart meters

No access to specific information

Manual Control

400-500 households with smart meters

Receiving simple market price information

Must move their energy consumption by themselves

Automatic Control

700 automated households with IBM-Green Wave Reality equipment and smart meters

All houses have heat pumps or electric heating – responding autonomously to price signals

Automatic Control

500 automated households with Siemens equipment and smart meters

All houses have heat pumps or electric heating – responding to aggregator control

Smart Businesses

Up to 100 costumers with smart meters

Include small business and public customers

Connected smart appliances responsive to control signals

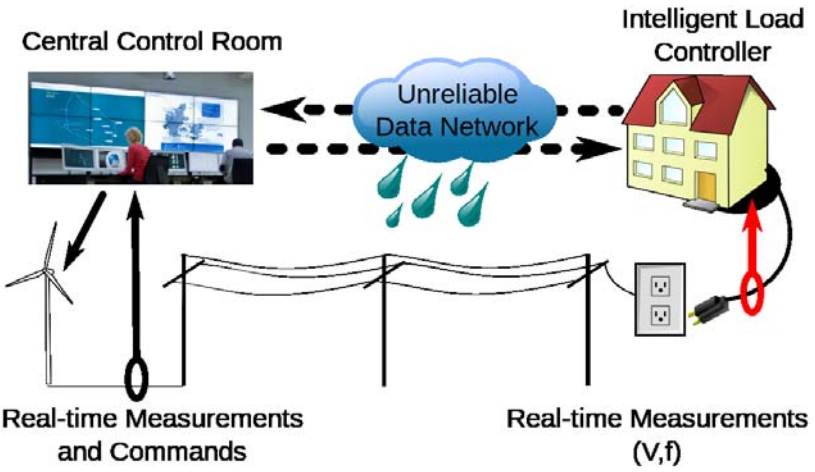
EcoGrid eu
www.eu-ecogrid.net

Full end-to-end demo 18-19 November 2014

www.ipower-net.dk

DTU

Autonomous Services from Demand



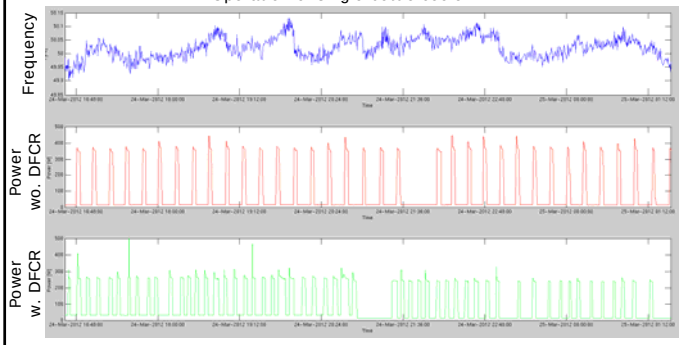
Demand Units Providing Frequency Controlled Reserves

Field Test at Bornholm with 200 units (heating, cooling, industry)

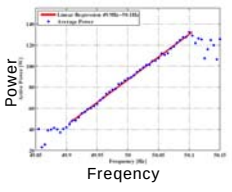
Demand Units Providing Frequency Controlled Reserves

Field Test at Bornholm with 200 units (heating, cooling, industry)

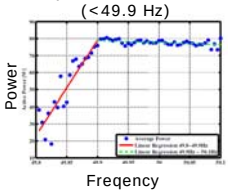
Operation of single bottle cooler:



Delivery of normal reserve (49.9-50.1 Hz)



Delivery of disturbance reserve (<49.9 Hz)



- Demand can deliver frequency controlled reserves which today are delivered by large power plants
- Frequency reserves costs 8.000-22.000 €/MW/year in DK
- Pay pack time: **1-2½ year** w/ 1 kW unit

Conclusion

- **Energy flexibility** will play an increasingly important role and get a higher value in the future energy system with high share of renewables
- By **being flexible** the energy consumption can be 'green' and have lower energy costs. It can also lead to energy savings.
- **Promising near-term flexibility solutions** includes solutions utilising the build-in storage in the energy consumption processes and use of autonomous controllers
- The **market, regulatory framework and technologies** are currently being developed to enable and efficiently support flexibility from demand

Thank you for the attention!

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